AMBIENT AIR QUALITY
IN
WINDSOR AND VICINITY

ANNUAL REPORT 1981

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Ontario
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Environment

AMBIENT AIR QUALITY
IN
WINDSOR AND VICINITY

Annual Report 1981

Technical Support Section
Southwestern Region

ONTARIO MINISTRY OF THE ENVIRONMENT
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SUMMARY

Air quality monitoring conducted in the Windsor area by the Ministry of the Environment revealed satisfactory air quality with respect to many air pollutants and improvement in some air pollutants that have not yet been reduced to satisfactory levels. Levels of sulphur dioxide, carbon monoxide, nitrogen dioxide and heavy metals compared favourably with Ontario's criteria for desirable ambient air quality.

During 1981 particulates, measured as dustfall and total suspended particulate matter, exceeded the criteria for desirable ambient air quality. However, particulate levels were lower in 1981 than in previous years. Evaluation of the particulate data along with meteorological information and knowledge of emission sources indicates impacts from the long-range transport of particulates, industries in the Zug Island area of Wayne County, Michigan, road traffic and the scrap metal recycling operations of Zalev Bros. Ltd.

Malodours in west Windsor are probably, in part, attributable to ambient levels of total reduced sulphur compounds emitted from the Zug Island area. Levels of total reduced sulphurs monitored in west Windsor were appreciably higher when winds were blowing from the direction of Zug Island.

Levels of photochemical oxidants were again unsatisfactory in Windsor and throughout southern Ontario. Elevated levels are partly a result of local emissions but to a greater degree are a result of the long-range transport of oxidants and precursor chemicals. Ontario has established a special section in its Long-Range Transport of Air

Pollutants program to study the oxidant situation. With assistance from many groups, including this Ministry, the State of Michigan conducted a special study during 1981 in order to develop a control strategy for oxidants. The U.S. Environmental Protection Agency is requiring individual states to implement oxidant control strategies which show attainment of the ozone standard by 1987.

From time-to-time fluoride levels exceed the levels for desirable ambient air quality. The desirable levels were established for the protection of vegetation and no damage attributable to fluorides was found in the Windsor area during 1981.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors in the Windsor area to measure levels of a number of pollutants that may adversely affect health, vegetation or the enjoyment of property. Data on the levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore the effectiveness of pollution abatement. As well, information is provided on the effects of specific sources of pollutants and for use in the formulation of strategies to control emission sources. The air quality monitoring program is complemented by the Ministry's phytotoxicology surveys which determine effects of air pollutants on vegetation.

During the fall of 1981, the Ministry received a number of complaints about odours when winds were blowing towards west Windsor from the general direction of Zug Island. For a week in December a mobile air monitoring unit

equipped with a gas chromatograph attempted to identify the constituent or constituents in the ambient air causing the offensive odours. Unfortunately, meteorological conditions were not conducive to identifying the causes of the malodorous conditions. The mobile unit is to return to Windsor in 1982 to repeat its efforts. A total reduced sulphur monitor was establish at a fixed site in west Windsor to obtain information on odorous sulphur compounds.

In accordance with the Memorandum of Understanding on Transboundary Air Pollution Control in Southwestern Ontario - Southeastern Michigan signed in 1974 by Premier Davis and Governor Milliken there are regular exchanges of both air quality data and reports on progress of compliance with abatement schedules. The information exchanged is used by the International Joint Commission, the International Michigan - Ontario Air Pollution Board and the Michigan - Ontario Transboundary Air Pollution Committee to prepare annual reports on air quality and pollution abatement programs.

This annual report deals more specifically and comprehensively with ambient air quality in the Windsor area than do the international reports.

DESCRIPTION OF MONITORING NETWORK

The Ministry operates continuous and intermittent ambient air monitors at fixed sites throughout the Windsor area. Ideally, monitoring would be conducted at the same sites year after year in order to provide a historical trend for air quality. However, many stations have had to be relocated or terminated because of local interferences or changing land-use patterns. Nevertheless, the number of

existing historical stations is deemed adequate to evaluate the long-term trend in levels of pollutants.

Monitoring sites are distributed more densely in the downtown area where emissions from motor vehicles and commercial establishments are most prevalent and in west Windsor, which is close to a heavily industrialized portion of Wayne County, Michigan. The locations of the Ministry's monitoring stations in the Windsor area are illustrated in Figure 1 and are described in Table A1 of Appendix 1.

Also shown in Figure 1 are the locations of 5 monitoring sites at which Ontario Hydro operates sulphur dioxide monitors. The sulphur dioxide monitors of Ontario Hydro are located in different directions from the J. C. Keith Generating Station at distances ranging from 5 to 7 kilometres.

The pollutants monitored at the various Ministry stations are indicated in Appendix 1, Table A2. Ontario's criteria for desirable ambient air quality with respect to these pollutants and the prime factors supporting these criteria are contained in Appendix 1, Table A3.

METEOROLOGICAL DATA

Meteorological data for 1981 were obtained from station 12001 in west Windsor. Station 12001 has a meteorological tower operated by Ontario Hydro. Wind speed, wind direction and ambient temperature are measured continuously at 18 metres above ground level. At 80 metres above ground level the difference between the temperature at the 80-metre level and the 18-metre level is determined and as well, wind speed and direction are measured. The meteorological data

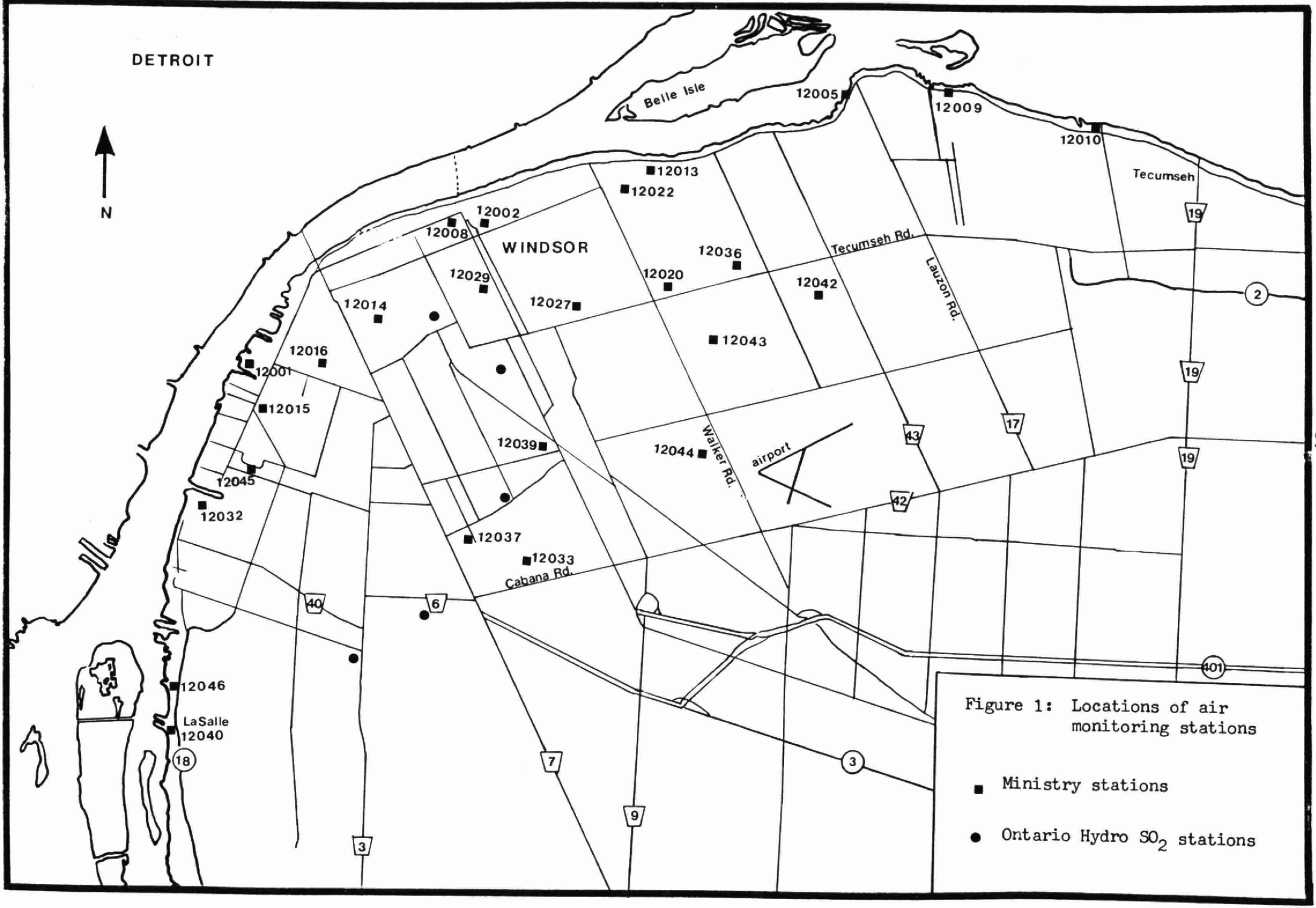


Figure 1: Locations of air monitoring stations

■ Ministry stations

● Ontario Hydro SO_2 stations

are telemetered to a Ministry of the Environment computer in Toronto 12 times per hour.

Prior to 1981, meteorological data were obtained from stations 12032 and 12034 but it was necessary to suspend measurement of meteorological parameters at these sites in 1980.

Meteorological data are correlated with other pollutants such as suspended particulates, sulphur dioxide and ozone to determine sources of pollutants. The data are also used to forecast dispersion conditions in association with the Air Pollution Index.

PARTICULATES

The iron and steel industry, foundries, power generating plants utilizing fossil fuels and road traffic are primary sources of particulates that adversely affect air quality in Windsor. Wind-blown particles from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as suspended particulates, dustfall and soiling index. Levels of suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. At 2 sites, stations 12005 and 12015, suspended particulates were also divided into different size fractions and collected by cascade impactor samplers.

Dustfall is measured by exposing an open cylinder (jar) of known diameter for 30 days and subsequently weighing the amount of particulates collected in the jar.

This is a simple but crude sampling mechanism which is subject to many interferences and inaccuracies. Nevertheless, it does serve to show a general historical trend and relative levels of particulates in the Windsor area.

Soiling index is determined by measuring the difference in the amount of light transmitted through a filter before and after ambient air is drawn through the filter for periods of 1 or 2 hours. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Light transmitted through the filter is measured by a photoelectric cell and the soiling index may be calculated immediately. This immediate availability of the soiling index in contrast to the time-consuming laboratory analysis required for total suspended particulate measurements has resulted in the soiling index being used in the Air Pollution Index as an indicator of levels of suspended particulates.

SUSPENDED PARTICULATES

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period. The other is an annual geometric mean of 60 ug/m^3. The criterion for 24 hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1981 filters were exposed to collect suspended particulate matter at 13 sites in the Windsor

area. At all sites except station 12008 samples were collected on a frequency of every sixth day. At station 12008 sampling started on an every-sixth-day frequency but late in January was changed to daily sampling. The purpose of the every-day sampling is to provide data by which the representativeness of the data collected on the every-sixth-day schedule may be judged.

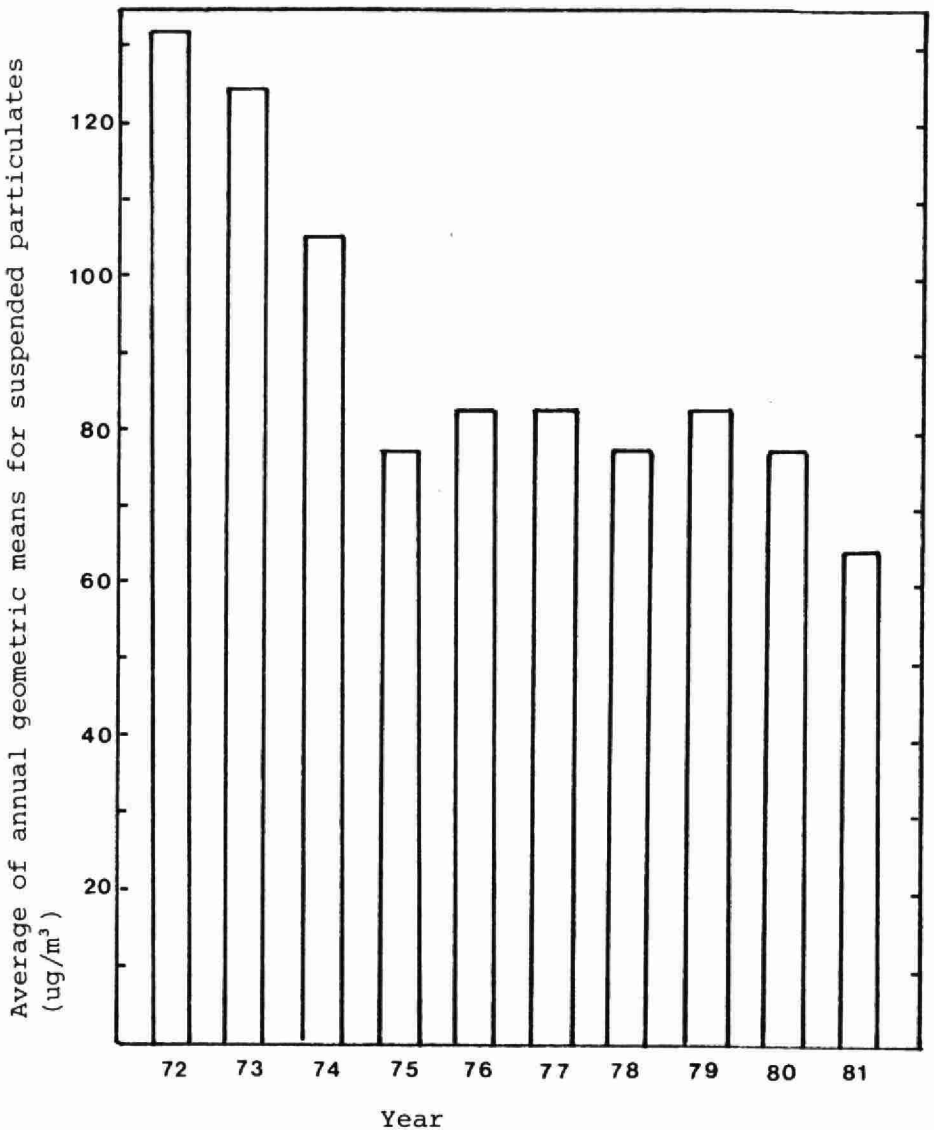
During 1981 the measured levels of total suspended particulate matter were appreciably lower than in previous years. The degree of improvement in total suspended particulate levels is illustrated in Figure 2 which shows the average of the annual geometric means and the average of the frequency of values above the 24-hour criterion for 8 monitoring stations in operation since 1972.

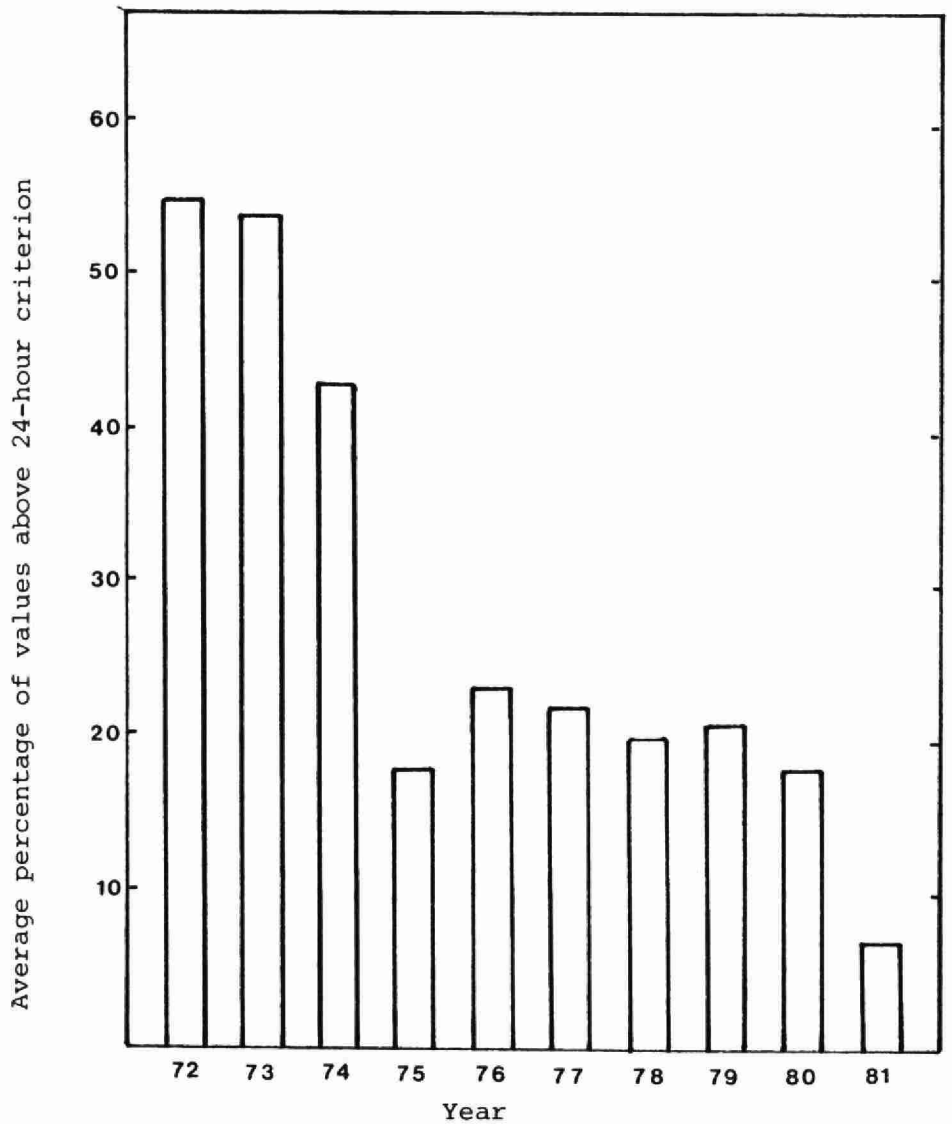
The improvement is further shown by the annual criterion for desirable ambient air quality being met at 6 sites in 1981 compared to 4 in 1980. The best record prior to 1980 was to meet this criterion at 2 sites. Also the 24-hour criterion was met continuously at 2 sites compared to the best previous record of meeting it at 1 site - first accomplished in 1979 and repeated in 1980. A summary of the data for 1972 to 1981 is presented in Appendix 2, Table A4.

The daily sampling at station 12008 reveals that the every-sixth-day sampling schedule utilized for the other monitoring sites during 1981 would provide annual geometric means representative of the year. The annual geometric mean for station 12008 based on daily sampling is 58 ug/m^3 compared to 60 ug/m^3 which is the annual geometric mean calculated from the every-sixth-day schedule.

With respect to the 24-hour criterion the every-sixth-day schedule probably indicated better conditions than those actually experienced for the complete year. This

Figure 2. Trend in levels of suspended particulates based on averaged data from eight monitoring stations





statement is based on the 24-hour criterion being exceeded by 20 of 314 (6.4 percent) samples collected at station 12008 in 1981 compared to only 2 of 57 (3.5 percent) samples collected on the every-sixth-day schedule exceeding the criterion.

Figure A1 of Appendix 2 illustrates the annual geometric mean concentrations and the percent frequencies of excursions above the 24-hour criterion at the approximate locations of the monitoring stations. Higher annual geometric means and higher frequencies of excursion above the 24-hour criterion occur in west Windsor which is immediately downwind of the prevailing winds from a heavily industrialized area of Wayne County, Michigan.

Station 12013 is in the vicinity of the casting plant of Ford Motor Company of Canada, Limited. Levels of suspended particulates were appreciably lower in 1980 than in previous years and levels determined in 1981 were appreciably lower than those of 1980. The improvement is attributed to improved particulate control facilities and restricted production during 1980 and 1981.

Correlations between 1981 levels of total suspended particulates and wind direction were determined for the 13 monitoring sites for particulates and wind direction measured at the lower level of station 12001. The correlations are presented in Figure A2 of Appendix 2 with the longer lines indicating higher correlations between elevated levels of particulates and wind direction. For all monitoring sites a relatively strong correlation exists for south-southwesterly winds. This influence is probably attributable, in part, to long-range transport of aerosols including sulphates and products of photochemical reactions. The south-southwest correlations are generally stronger at sites that experience lower levels of total suspended

particulates and are not close to appreciable point sources of particulates. Correlations for stations 12015, 12016 and 12032 indicate an influence from the heavily industrialized area of Detroit. Correlations for stations 12014 and 12039 reflect an influence from roadways to the south. At station 12014 lead levels in the total suspended particulates were acceptable but higher than at other sites in Windsor (see sub-section Chemical Analysis of Suspended Particulates). This reaffirms the influence of roadway emissions (leaded gasoline). Total suspended particulates collected at station 12039 were not analyzed for lead. The correlation for station 12039 also show an influence from the east-northeast where the scrap metal recycling operation of Zalev Bros. Ltd. is located.

During 1981 information on the size ranges of total suspended particulates were determined for a station (12005) with acceptable levels of particulates and at a station (12015) with unacceptable levels. At station 12005 the annual geometric mean met the annual criterion for desirable ambient air quality and the 24-hour criterion was exceeded by only 1 of 59 samples collected in 1981. At station 12015 the annual geometric mean has routinely exceeded the annual criterion and the 24-hour criterion was exceeded by 9 of 55 samples collected during 1981. Utilizing 5-stage Andersen cascade impactors and standard high volume total suspended particulate samplers, 34 samples of different size fractions of particulate were collected simultaneously with 24-hour total suspended particulate samples at station 12005. At stations 12015, 28 samples of different size fractions were collected simultaneously with 24-hour high volume samples. A summary of the data appears in Table A5, Appendix 2. Levels of suspended particulates for the different size fractions are greater at station 12015 than at station 12005. The proportion of larger particles (greater than 7 microns) to smaller particulates

(less than 1.1 micron) is essentially equal for both monitoring sites. When more data are gathered, the size fraction information may be useful in determining the source of elevated levels of particulates, i.e., small particles associated with long-range transport of pollutants or larger particles emitted locally. The information may be used to determine what control strategies would be most effective. Also, since smaller sized particles have a greater potential for being detrimental to health, the information will be used to determine if a trend of increasing levels of smaller particulates exists.

A number of researchers have investigated the impact of passive loading on total suspended particulate loadings as determined by the high volume filter method. Passive loading refers to particulates that accumulate on the filter when the filter is not in its 24-hour sampling phase. Consequently, the passive loading is made up of particulates that are deposited on the filter before and after the 24-hour sampling period. During 1981, the passive loading for samples collected at station 12015 was measured to be 14 percent. If the passive loading was subtracted from the annual geometric mean for 1981 the mean would be reduced to 76 ug/m^3 from 87 ug/m^3. The frequency of exceeding the 24-hour criterion would be reduced to 7 percent from 17 percent. Investigations are currently being conducted into ways of counteracting or eliminating passive loading.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 8 stations in Windsor were analyzed quantitatively for cadmium, chromium, copper, iron, lead, manganese, nickel, nitrates, sulphates and vanadium. In addition, analyses for fewer parameters were

conducted for 3 additional stations. A summary of these data collected from 1976 through 1981 is presented in Appendix 2, Table A6.

Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium (see Table A3). Concentrations of the various metals have been low with no values above the criteria. Most metals show a trend of reducing levels since 1976. The reducing trend for lead is attributable to the greater use of low-lead gasoline. Average levels of lead were highest at station 12014 during 1981 and this probably reflects an impact from motor traffic on nearby arteries.

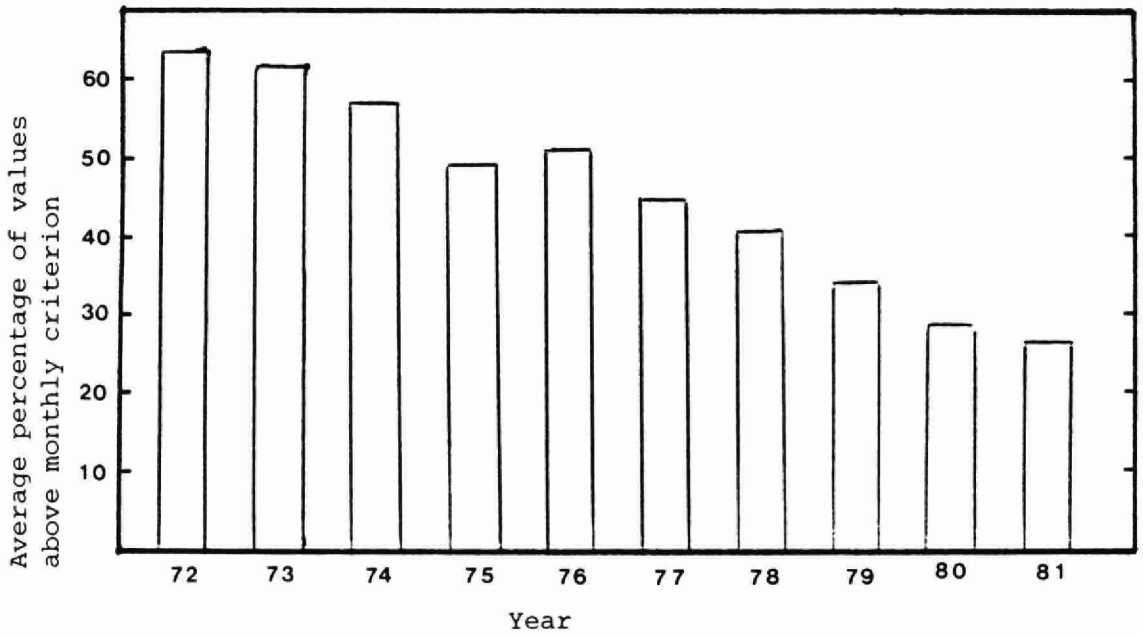
Iron levels at station 12013, near the casting plant of Ford Motor Company of Canada, Limited, and station 12039 were appreciably lower in 1981 than in previous years. Better pollution control facilities and restricted production in 1981 accounts for part of the reduction in levels of iron at station 12013. The improvement at station 12039 may be a result of more favourable meteorology and/or better control of emissions at Zalev Bros. Ltd.

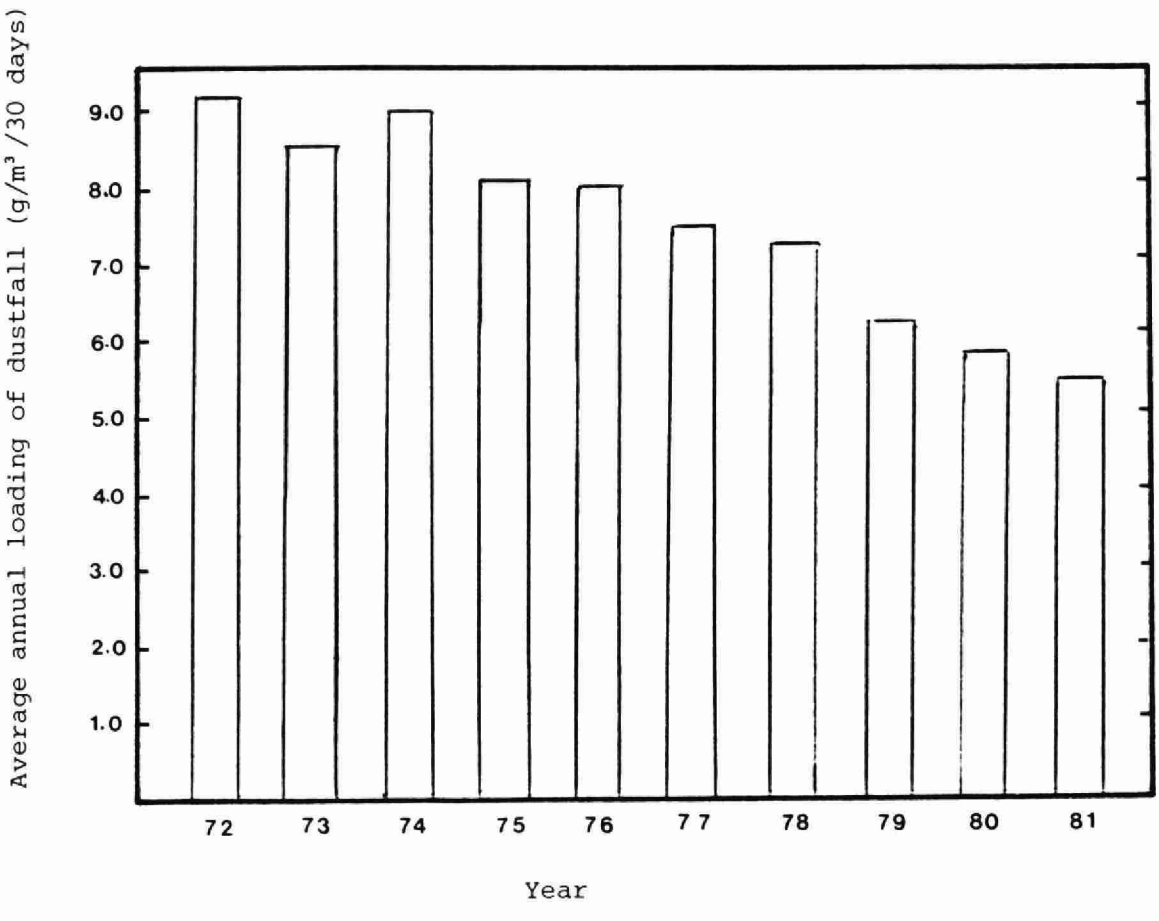
DUSTFALL

The criteria for desirable ambient air quality established for dustfall are a 30-day loading of 7.0 grams of dustfall per square metre ($g/m^2/30$ days) and an annual average of 4.6 $g/m^2/30$ days. These criteria were established on the basis of historical data and standards developed by other regulatory agencies.

In general, dustfall levels have been decreasing in recent years. The trend towards lower levels of dustfall is illustrated by Figure 3, which shows a decrease in the

Figure 3. Trend in dustfall levels based on averaged data for fourteen monitoring stations.





arithmetic mean of annual averages for 14 monitoring sites which have been in operation since 1972. A decrease in the arithmetic mean for the frequencies of excursions above the 30-day criterion is also evident.

Notwithstanding the downward trend in dustfall levels, during 1981 the annual criterion was exceeded at 11 of the 21 sites where dustfall is measured. The 30-day criterion was exceeded at 14 of the 21 monitoring sites in 1981. As would be expected, dustfall levels are higher in west Windsor, LaSalle and the more commercial areas of the City than in the outer residential areas. Figure A3 shows the annual averages for dustfall and the frequencies of excursions above the 30-day criterion as determined for the different monitoring stations during 1981. The 1981 dustfall values are listed in Table A7 of Appendix 2.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. The primary emitters of sulphur oxides are power plants and industries utilizing fossil fuels to meet requirements for large amounts of energy.

During 1981 sulphur oxides were measured in Windsor as gaseous sulphur dioxide and as sulphate in suspended particulate matter. Data for sulphate in suspended particulates are presented in the summary table (Table A6) supporting the section on the Chemical Analysis of Suspended Particulates.

SULPHUR DIOXIDE

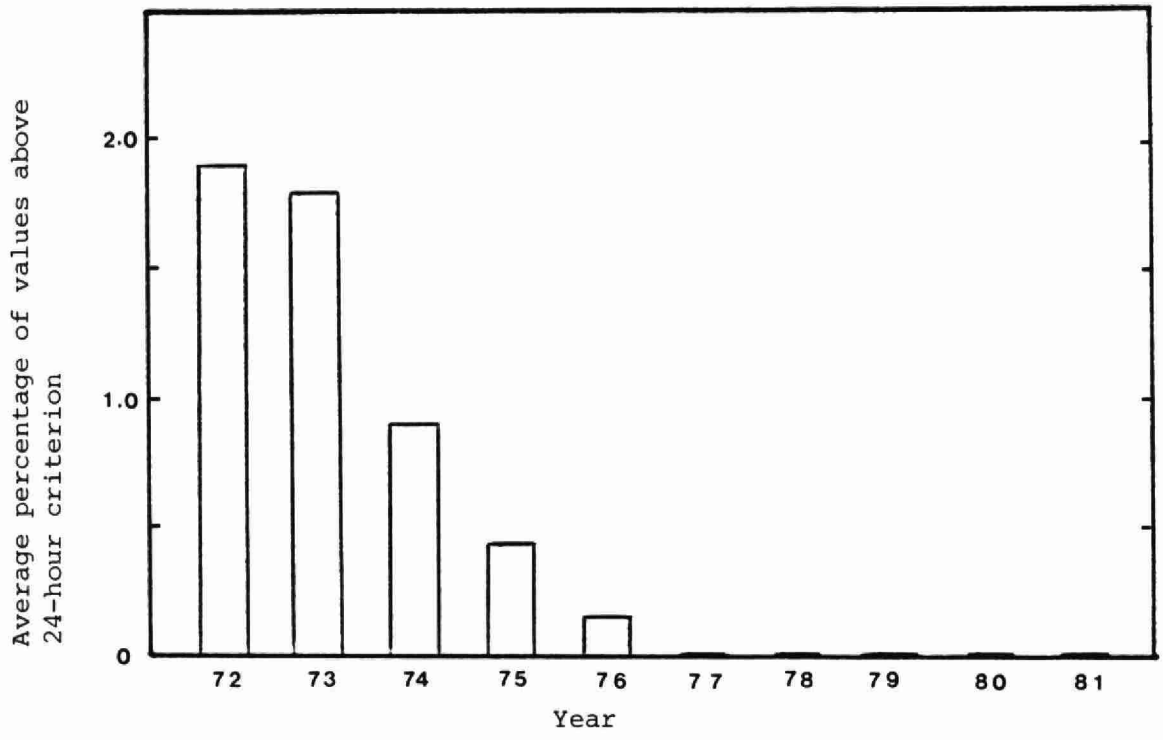
The criteria for desirable ambient air quality with respect to sulphur dioxide are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for 1 hour, 0.10 ppm averaged for 24 hours (midnight to midnight) and 0.02 ppm as an annual average. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion serves to protect human health.

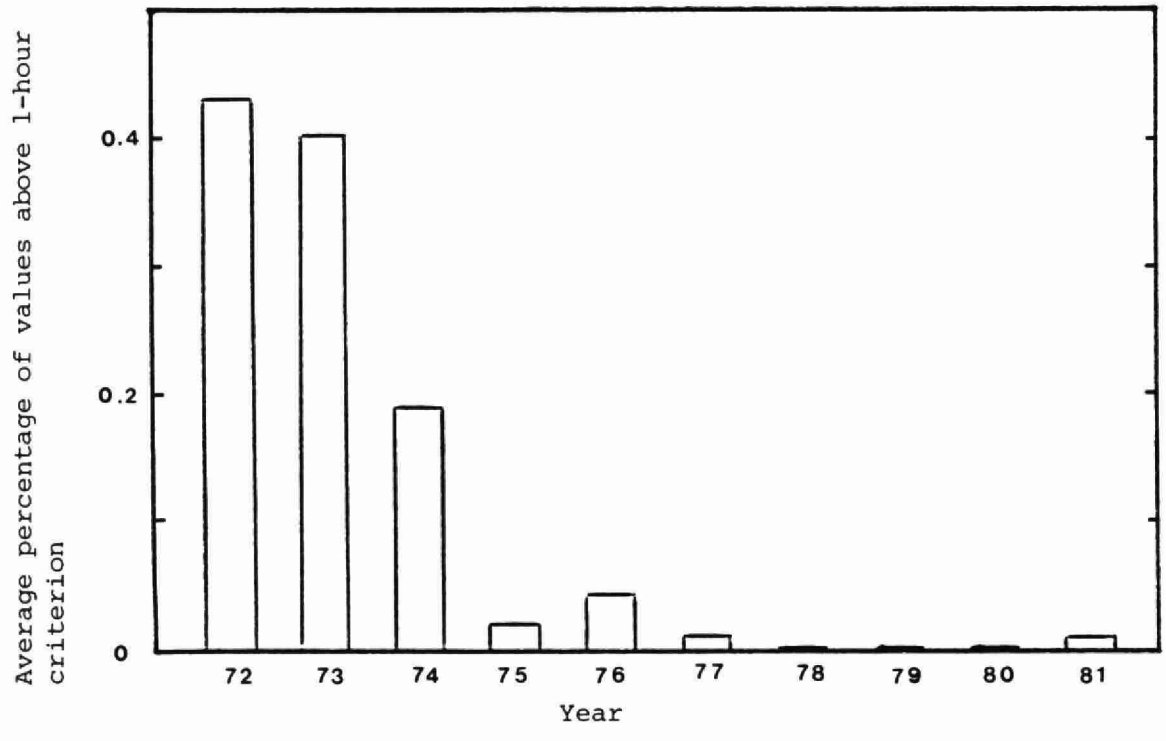
During 1981 gaseous sulphur dioxide was measured continuously by the Ministry of the Environment at four fixed locations in Windsor. The monitoring locations are shown on Figure 1 as stations 12008, 12013, 12016 and 12032. The monitors utilized are continuous fluorescence-type instruments. The 24-hour and annual criteria were not exceeded at any of the 4 monitoring sites. The 1-hour criterion was not exceeded at either station 12016 or 12032 but was exceeded for 1 hour at both stations 12008 and 12013. Considering that there were 8,371 measurements conducted at station 12008 and 7,770 measurements conducted at station 12013 the measurement of the 1-hour excursions above the criterion are not considered to reflect unsatisfactory air quality. These excursions could not be attributed to any specific source. A summary of the 1981 Ministry data for sulphur dioxide is presented in Table A8, Appendix 3.

Although the data are not presented in this report, the criteria for desirable ambient air quality for sulphur dioxide were met during 1981 at the 5 monitoring sites maintained by Ontario Hydro in the Windsor area.

Levels of sulphur dioxide have been appreciably lower in recent years than during the early 1970's. The improvement is illustrated by Figure 4 which shows the frequencies of excursions above the 1-hour and 24-hour criteria for sulphur dioxide as measured at stations 12008

Figure 4. Trend in frequencies of excursions for sulphur dioxide based on combined data from stations 12008 and 12032.





and 12032. The improved air quality is attributable to better control and dispersion of emissions of sulphur dioxide in Wayne County, Michigan and Windsor.

Pollution roses for 1981 levels of sulphur dioxide are presented for each monitoring station in Figure A4, Appendix 3. The roses were developed by determining the average concentrations of sulphur dioxide that corresponded to 16 wind directions. Data for wind direction were measured at the 18-metre level of station 12001. The pollution roses indicate an influence from sources of sulphur dioxide in Wayne County, Michigan, but these were not sufficient to cause significant excursions above the criteria for desirable ambient air quality.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of deteriorating air quality conditions that are numerically reported as the API.

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are used to compute 24-hour running averages which are inserted into the following equation:

$$API = 0.78\ (18.26\ COH + 156.7\ SO_2)^{1.06}$$

where: COH is the 24-hour average for soiling index expressed in co-efficient of haze units

SO_2 is the 24-hour average concentration of sulphur dioxide expressed in parts per million

API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emitters are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. When the API reaches 100 all industries and other contributors of pollution not essential to public health and safety can be ordered to cease operation.

Levels of soiling index and sulphur dioxide utilized for the computation of the API are obtained at station 12008, in downtown Windsor, and at station 12016 in west Windsor. At station 12016 the API did not reach the Advisory Level of 32. The Advisory Level was reached at station 12008 on two occasions. On November 4, 1981 the API reached 33 for two consecutive hours and on November 17, 1981 the API exceeded 32 for 21 consecutive hours. The maximum API was 42 on November 17. The deteriorated air quality on November 4 and 17 was attributable to elevated levels of particulates. Sulphur dioxide levels were normal. These API excursions above 32 were the first since 1978.

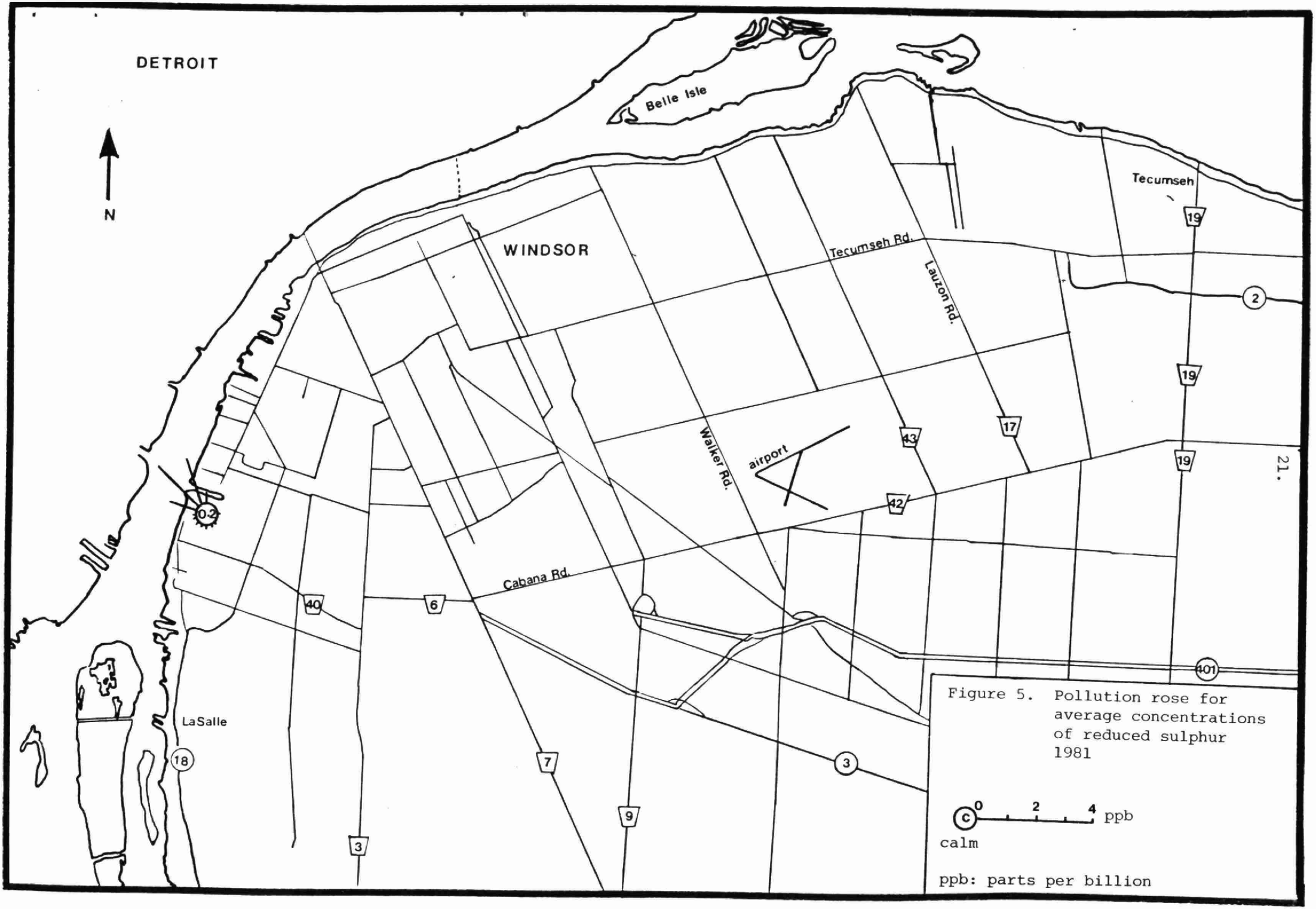
TOTAL REDUCED SULPHUR

Gaseous total reduced sulphur compounds often exhibit malodours at very low concentrations. Hydrogen

sulphide is a reduced sulphur compound commonly referred to as rotten egg gas. Mercaptans are also reduced sulphur compounds. There are many sources of total reduced sulphurs including natural decomposition of organic material. In west Windsor there are occasional malodours which may be caused by hydrogen sulphide, mercaptans or other reduced sulphur compounds. A possible source of these odours is the coking operations of the steel industry in Wayne County, Michigan.

In May 1981 a total reduced sulphur instrument began operation at station 12032 in west Windsor. There were 5406 hourly concentrations of total reduced sulphur determined. The maximum concentration was 37 parts per billion (ppb) and 24 values were greater than 10 ppb. The Ministry of the Environment has a desirable ambient air quality criterion for mercaptans of 10 ppb during a 1-hour period. This criterion was established on the basis of odour. The analytical results indicate that some of the offensive odours in west Windsor may be attributable to reduced sulphur compounds. A summary of the results appears in Appendix 4, Table A9.

The total reduced sulphur concentrations were correlated with wind direction data obtained at station 12001 in Windsor. The resulting pollution rose which is depicted on Figure 5 indicates that reduced sulphur levels are appreciably higher when winds are blowing from the general direction of the coking ovens and other heavy industry operations in the Zug Island area of Wayne County.


DETROIT
Belle Isle
N
WINDSOR
Tecumseh
Tecumseh Rd.
Lauzon Rd.
Walker Rd.
airport
Cabana Rd.
LaSalle
21.
Figure 5. Pollution rose for average concentrations of reduced sulphur 1981
0 2 4 ppb
calm
ppb: parts per billion

CARBON MONOXIDE

Combustion processes account for man's major emissions of carbon monoxide. Emissions from motor vehicles are especially significant because they occur near ground level and are concentrated in urban areas where the public may be exposed for long periods. Major industries and power generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in ambient air.

The criteria for carbon monoxide are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8 hours. These criteria were established for the protection of human health and have not been exceeded in the past 6 years, based on monitoring at station 12008. Since this station is located in the downtown area of Windsor where the highest levels of carbon monoxide are anticipated, there is a high probability that levels are acceptable throughout the Windsor area.

A summary of data for carbon monoxide, obtained since 1972, is presented in Appendix 4, Table A9. Data obtained from 1972 to 1976 are higher than data for the past 5 years. The differences in measured levels are attributed in part to replacement in late 1976 of a less accurate monitoring unit with a more sophisticated monitor.

OXIDES OF NITROGEN

Like many other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxides and nitrogen dioxide are of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria for nitrogen dioxide, which are based on the protection of human health and offensive odours, are 0.20 ppm averaged for 1 hour and 0.10 ppm averaged for 24 hours (midnight to midnight).

During 1981 the criteria were not exceeded and in general 1981 levels of nitrogen dioxide and nitric oxide were comparable to those of 1980. Since 1979 nitric oxide levels have been lower than previous years. The data were determined by a continuous chemiluminscence monitor located at station 12008 in downtown Windsor. Since emissions from motor vehicles are concentrated in the downtown area, levels of oxides of nitrogen would probably be lower in other areas of Windsor. A summary of the data for oxides of nitrogen is presented in Table A9, Appendix 4.

Although levels of nitrogen dioxide have been very favourable when compared to the criteria, there is concern about oxides of nitrogen because of acidic precipitation and their role in the formation of unsatisfactory levels of photochemical oxidants. Consequently, controls for oxides of nitrogen are being carefully considered.

HYDROCARBONS

The principle man-made source of hydrocarbons is emissions from motor vehicles. Other significant man-made sources are incomplete combustion of fuels by industries and power plants, and evaporation losses during the storage and transportation of hydrocarbons. In the Windsor area hydrocarbon emissions from distilleries and distillery warehouses account for a large proportion of the emissions from stationary sources. Natural phenomena produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Although there are no criteria for total hydrocarbons, monitoring for them provides information on trends in levels of hydrocarbons. Increasing levels of hydrocarbons could be significant should they be attributable to detrimental compounds. Furthermore, the non-methane hydrocarbons or "reactive" hydrocarbons may partake in photochemical reactions which produce excessive levels of oxidants.

Total hydrocarbons, methane and non-methane hydrocarbons are monitored continuously at station 12008 in downtown Windsor, using flame ionization detection. Levels of total hydrocarbons in 1981 were similar to levels of previous years and no trend of increasing or decreasing levels is apparent. Monitoring of non-methane hydrocarbons began in November 1980 and the average of 14 months of data reveals non-methane hydrocarbons accounting for approximately 20 percent of the total hydrocarbons. A summary of annual average concentrations appears in Table A9, Appendix 4.

OXIDANTS

A major portion of the oxidants in ambient air are a result of photochemical reactions and inter-reactions involving oxides of nitrogen and hydrocarbons. The reac-

tions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine. Consequently, higher levels of oxidants are experienced in the spring and summer months.

Ozone normally accounts for 80 to 90 percent of the photochemical oxidants in ambient air and the monitoring technology for ozone is more accurate and efficient than that for total oxidants. For these reasons, most regulatory agencies, including this Ministry, monitor for ozone rather than total oxidants.

Ozone is also present in the stratosphere where it plays the critical role of absorbing ultraviolet radiation that in excessive amounts may be biologically harmful. Occasionally, ozone from the stratosphere may be transported downwards to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) can account for a very significant portion of local levels of ozone. Long-range transport from distances greater than 200 kilometres has been reported in the literature. Consequently, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

The Environmental Protection Agency (EPA) in the United States has established a primary standard for ozone of 120 parts per billion (ppb) averaged over a 1-hour period. Areas exceeding this standard will be required to develop a State Implementation Plan (SIP) by 1982. The SIP is to outline the actions required to bring ozone levels

into compliance with the standard by 1987. During 1981, Ontario participated with various groups from Michigan in a study which is to provide information pertinent for an ozone SIP for southeastern Michigan. Preliminary results from the study indicate that forecasted reductions in oxides of nitrogen and non-methane hydrocarbons in southeastern Michigan should satisfy the EPA requirements for an ozone SIP.

The Ontario criterion for desirable ambient air quality is 80 ppb of ozone averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects detrimental to health that are associated with oxidants are eye irritation and a decrease in performance during physical activities. Oxidant damage to crops in Ontario is estimated at millions of dollars annually. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant problem.

Ozone is monitored by a chemiluminescence-type instrument at station 12008, in downtown Windsor. During 1981 there were 107 hourly values reported in excess of the 1-hour criterion, all of which occurred during the months May through September. With the formation of ozone photochemically being dependent on meteorological conditions, there may be large fluctuations from year to year in the frequencies of excursions above the criterion. A summary of ozone data is presented in Appendix 4, Table A9, which indicates that the frequencies of excursions were lower than normal during 1981.

A pollution rose, showing the frequency of ozone values above 80 ppb related to wind speed and direction, appears in Appendix 4, Figure A5. The majority of the

excursions above 80 ppb are associated with winds from the southwest to the southeast with the greatest frequency (28 percent) associated with south-southeast winds. Most of the excursions associated with southerly winds are a result of long-range transport of ozone and its precursors and the ozone SIP for southeastern Michigan will not reduce the frequency of these excursions. However, ozone SIPs implemented in other major U.S. centres may have a positive impact on these excursions.

FLUORIDES

Sources of fluorides in the Windsor area are the steel industry located in the downriver area of Wayne County, Michigan, power plants where the coal burned contains trace amounts of fluorides, fluorspar unloading operations at docks in west Windsor and subsequent trucking of fluorspar to a location south of Windsor.

Fluoridation rate is a measurement designed to indicate the relative amount of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and then analyzed for fluoride content. This monitoring technique measures primarily gaseous fluoride but some fluoride in particulate form may be collected on the filter.

The criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. Consequently, a criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ugF/100 cm^2/30 days) has been established for the growing season from April 15 to October 15 while a criterion of 80 ugF/100 cm^2/30 days applies to the period of October 16 to April 14. Since the months of April and

October are common to both criteria and fluoridation rate is measured on a monthly basis, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ugF/100 cm^2/30 days). In recent years, investigations of vegetation have not revealed any appreciable damage to vegetation in Windsor attributable to fluorides.

During 1981 there were eight sites where fluoridation rates were monitored, 5 in west Windsor and 3 in the downtown area. The criteria were exceeded at 4 of the 5 sites in west Windsor and 1 site in downtown Windsor. Figure A6, Appendix 5, shows that during 1981 higher annual averages for fluoridation rates occurred in west Windsor than in downtown. The 1981 fluoridation rates appear in Table A10, Appendix 5.

Fluoridation rate is not considered a sensitive indicator of temporal trends of fluorides. However, based on data from six monitoring sites in operation since 1972, the annual averages for fluoridation rate and the frequency of excursions above the criteria have been lower in recent years. Values for 1981 are higher than 1979 and 1980 values. Figure A7 depicts the trend in fluoridation rates.

APPENDIX 1

DESCRIPTION OF MONITORING NETWORK

Table A1. Locations of air monitoring stations

Station number	Location	Universal transverse mercator projection co-ordinates	Elevation above sea level (metres)	Air intake height (metres)
12001	1.1 km NNE of J. C. Keith Generating Station	03276 - 46839	180	18 & 80
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12005	7730 Riverside Drive East	03395 - 46890	177	10
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12014	College/California Street	03304 - 46849	185	1
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12020	1869 Albert Street	03363 - 46854	183	5
12022	Hickory/Richmond Street	03352 - 46870	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12029	459 Ellis West	03323 - 46853	185	5
12032	Morton Dock	03271 - 46817	175	4
12033	3501 Longfellow	03335 - 46801	183	5
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12039	Dougall St./E. C. Row W	03337 - 46821	195	5
12040	225 Willow Drive (La Salle)	03261 - 46773	175	5
12042	Princess/Joinville Street	03384 - 46848	185	5
12043	Somme/Chandler	03366 - 46845	183	5
12044	Seymour/Turner	03366 - 46822	183	5
12045	Healy/Sandwich	03276 - 46822	183	5
12046	Adams/Hwy 18	03264 - 46778	175	5

Table A2. Parameters monitored in the ambient air in Windsor during 1981

Station Number	Air Pollution Index	Carbon Monoxide	Dustfall	Fluoridation Rate	Hydrocarbons	Meteorological Data	Nitric Oxide	Nitrogen Dioxide	Nitrogen Oxides	Ozone	Soiling Index (1-hr COH)	Sulphur Dioxide	Suspended Particulates
12001						X							
12002			X										X
12005			X										X
12008	X	X	X	X	X		X	X	X	X	X	X	X
12009			X										X
12010			X										X
12013			X									X	X
12014			X										X
12015			X	X									X
12016	X		X	X							X	X	X
12020			X										
12022			X	X									
12027			X	X									
12029			X										
12032			X	X								X	X
12033			X										
12036													X
12037													X
12039													X
12040			X	X									
12042			X										
12043			X										
12044			X										
12045			X	X									
12046			X										

Table A3. Desirable ambient air quality criteria established by the Ontario Ministry of the Environment

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Dustfall	7 grams/metre^2 in 30 days	Historial and in keeping with other control agencies
	4.6 grams/metre^2 (monthly average in 1 year)	
Fluoridation rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non-growing season)
Hydrocarbons (total)	None	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Nitric oxide	None	Reacts with oxygen to produced NO_2
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against odours
	0.10 ppm averaged for 24 hours	Protection of human health and protection against odours
Oxides of nitrogen	None	

Table A3. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation and human health
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m^3 averaged for 24 hours	Based on impairment of visibility and health effects
	60 ug/m^3 (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health
Lead in suspended particulates	5.0 ug/m^3 averaged for 24 hours	Based on protection of human health
	2.0 ug/m^3 as a geometric mean over a 30 day period	Based on protection of human health
Nickel in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of vegetation
Vanadium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health

APPENDIX 2

PARTICULATES

Table A4. Summary of data for total suspended particulates.

Station	Year									
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	Annual geometric means (ug/m³)									
12002	159	133	108	74	76	82	79	80	77	69
12005							I.D.	63	55	45
12008	126	126	116	82	80	87	80	80	71	58
12009	79	82	61	52	58	54	52	57	58	46
12010	85	86	58	46	54	47	46	53	47	40
12013	151	145	113	89	98	113	100	98	75	65
12014	152	148	139	95	94	96	77	103	92	74
12015	183	147	152	105	113	93	93	98	108	87
12016				88	88	95	84	85	83	67
12032	126	120	94	81	89	93	79	84	(88)	72
12036						72	63	72	70	55
12037						67	68	62	60	49
12039								79	71	71
	Percentage of values above 24-hour criterion									
12002	70	58	43	14	15	21	18	16	19	9
12005							4	4	2	2
12008	57	55	47	17	19	24	16	17	12	6
12009	16	25	10	2	5	7	9	4	9	0
12010	23	27	17	2	10	6	7	0	0	0
12013	65	69	44	26	37	40	40	42	15	5
12014	70	72	64	25	26	26	20	41	23	13
12015	80	66	84	33	42	25	27	33	46	16
12016				20	24	22	23	20	20	6
12032	53	53	30	21	27	25	19	16	(20)	7
12036						11	9	15	13	2
12037						10	15	2	2	2
12039								14	8	3

I.D. - Insufficient data to compute a representative geometric mean.

( ) - Annual geometric mean and percentage of values above 24-hour criterion based on data not representative of total year.

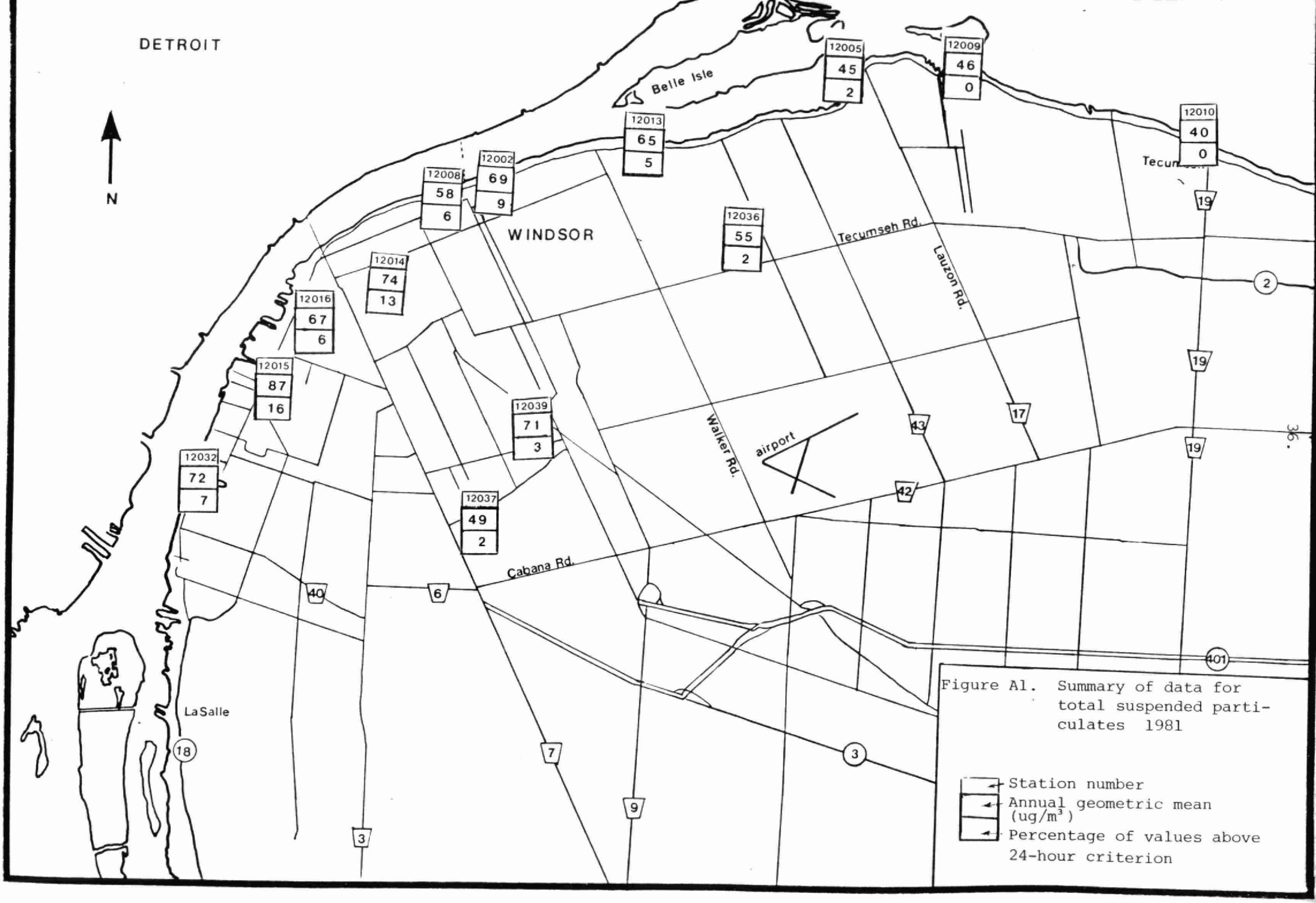


Figure A1. Summary of data for total suspended particulates 1981

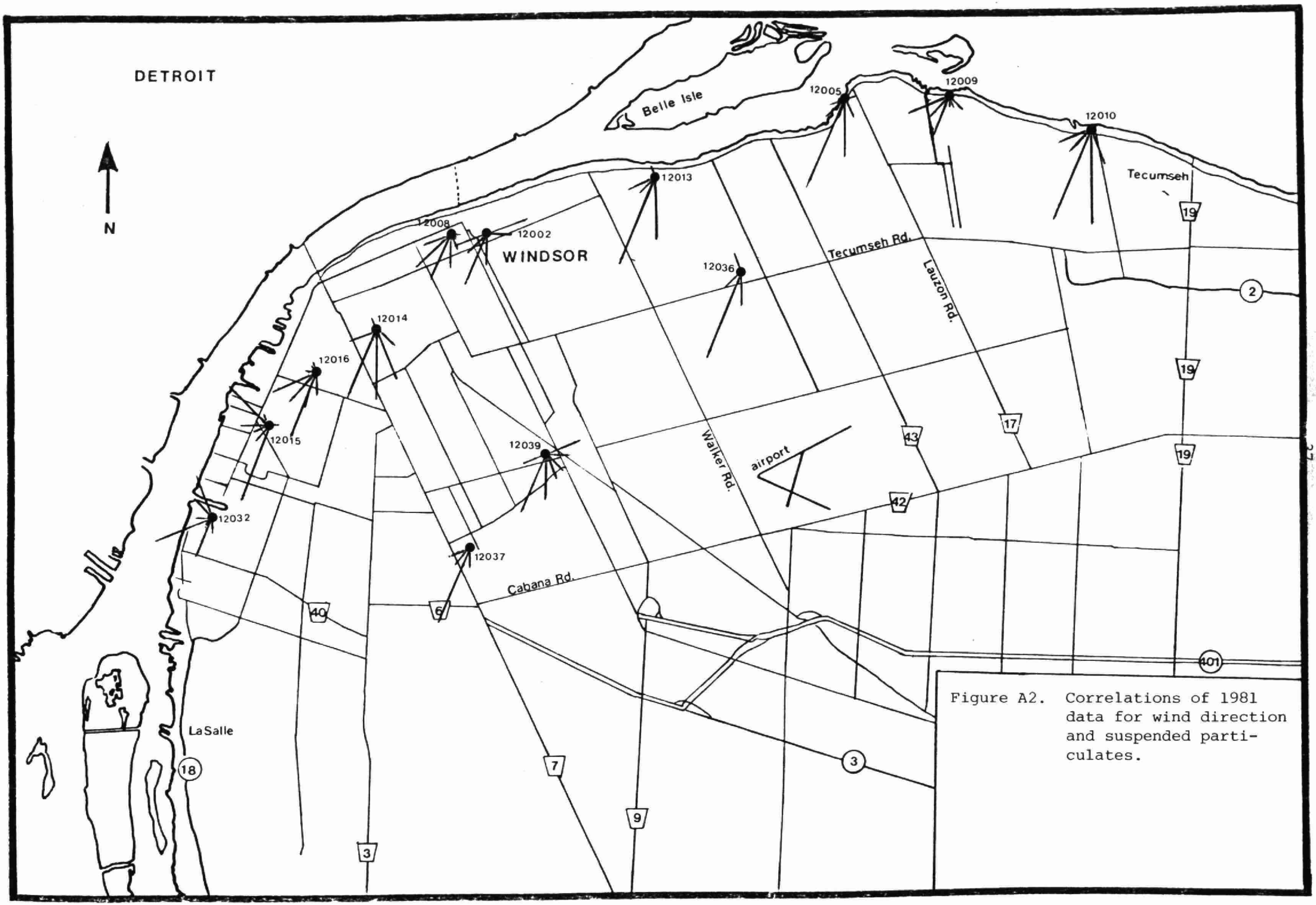


Figure A2. Correlations of 1981 data for wind direction and suspended particulates.

Table A5. Summary of distribution of suspended particulates in different size fractions

	Different size fractions of suspended particulates					Total suspended particulates (ug/m³)	
	greater than 7u	3.3 to 7u	2.0 to 3.3u	1.1 to 2.0u	less than 1.1 u	by summing size fractions	by standard hi-vol
Station 12005							
No. of samples	34	34	34	34	34	34	34
Average concentration (ug/m³)	18	11	7	9	15	60	52
Percentage of the sum of the size fraction concentrations	30	18	12	15	25	100	87
Station 12015							
No. of samples	28	28	28	28	28	28	28
Average concentration (ug/m³)	33	17	11	12	27	100	88
Percentage of the sum of size fraction concentrations	33	17	11	12	27	100	88

Table A6. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12002															
1976	12	0.003	0.010	12	0.007	0.022	12	0.11	0.36	12	3.4	8.2	12	0.7	1.1
1977	20	0.006	0.016	20	0.032	0.062	20	0.16	0.52	20	3.1	8.4	20	0.7	1.3
1978	24	0.007	0.035	24	0.018	0.045	24	0.23	0.62	24	3.1	9.9	56	0.7	1.5
1979	28	0.004	0.020	28	0.009	0.026	28	0.08	0.20	27	2.0	5.9	49	0.5	1.0
1980	23	0.002	0.008	23	0.006	0.015	23	0.06	0.16	23	1.5	3.2	51	0.4	2.1
1981	55	0.003	0.024	55	0.006	0.027	55	0.03	0.20	55	1.8	6.9	58	0.3	2.0
12005															
1981	59	0.003	0.035	59	0.004	0.030	58	0.05	0.27	59	1.2	13.0	59	0.3	2.6
12008															
1976	15	0.001	0.003	15	0.012	0.029	15	0.26	0.45	15	3.3	6.9	15	0.7	1.3
1977	18	0.008	0.025	18	0.018	0.074	18	0.42	1.07	18	4.0	11.1	18	0.8	1.7
1978	23	0.004	0.019	23	0.017	0.045	23	1.13	2.55	23	3.1	9.0	23	0.6	1.8
1979	34	0.004	0.023	34	0.008	0.036	34	0.49	1.62	34	1.9	6.3	34	0.4	1.0
1980	24	0.002	0.008	24	0.004	0.012	24	0.38	1.18	25	1.7	4.1	51	0.4	1.1
1981	307	0.003	0.042	307	0.005	0.043	307	0.15	0.82	307	1.6	7.2	316	0.4	2.0
12009															
1978													53	0.4	1.4
1979													47	0.2	0.8
1980													53	0.2	0.7
1981													43	0.1	0.4
12010															
1976	12	0.001	0.006	12	0.008	0.026	12	0.12	0.52	12	1.6	5.2	12	0.4	1.0
1977	20	0.002	0.006	20	0.009	0.029	20	0.08	0.24	20	1.2	5.5	20	0.4	0.9
1978	24	0.002	0.007	24	0.007	0.020	24	0.13	0.44	24	1.0	2.5	24	0.3	1.2
1979	32	0.002	0.005	32	0.003	0.015	32	0.19	0.79	32	0.9	2.1	32	0.2	0.6
1980	23	0.002	0.006	23	0.003	0.007	23	0.09	0.21	24	0.5	1.7	23	0.2	0.7
1981	55	0.002	0.012	55	0.004	0.031	55	0.10	0.50	55	0.9	4.4	55	0.2	0.6

Table A6. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12002															
1976	12	0.12	0.22	12	0.013	0.027	54	4.9	11.8	54	9.5	35.1	12	0.02	0.03
1977	20	0.11	0.32	20	0.025	0.073	56	4.9	21.6	56	12.5	35.5	20	0.04	0.14
1978	24	0.14	1.10	24	0.016	0.034	52	6.3	20.5	52	14.1	41.1	24	0.00	0.02
1979	28	0.08	0.20	28	0.009	0.015	49	6.8	17.8	49	13.4	28.4	28	0.00	0.03
1980	23	0.05	0.14	23	0.010	0.026	53	6.6	16.9	53	13.8	55.9	23	0.01	0.01
1981	55	0.06	0.20	55	0.011	0.070	58	7.0	19.4	57	13.1	29.7	12	0.01	0.02
12005															
1981	50	0.04	0.34	58	0.008	0.085	59	4.9	11.1	58	10.6	28.8	50	0.01	0.03
12008															
1976	15	0.11	0.28	15	0.051	0.409	105	4.8	21.6	104	10.7	39.7	15	0.17	1.47
1977	18	0.19	0.48	18	0.026	0.084	48	5.2	23.5	48	13.4	34.2	18	0.03	0.10
1978	23	0.12	0.31	23	0.026	0.059	55	5.3	20.5	55	14.3	57.1	23	0.00	0.03
1979	34	0.07	0.22	34	0.010	0.027	58	6.0	15.7	58	13.7	40.5	34	0.00	0.01
1980	24	0.06	0.15	24	0.014	0.049	52	5.5	16.2	52	11.8	31.0	24	0.01	0.01
1981	307	0.06	0.25	296	0.008	0.041	305	4.9	19.8	297	10.4	44.5	307	0.01	0.03
12009															
1979							24	5.2	13.4	24	11.8	25.4			
1980							55	5.3	17.5	55	11.6	24.6			
1981							43	4.5	13.7	41	10.2	26.4			
12010															
1976	12	0.06	0.19	12	0.003	0.021	51	3.6	14.2	51	6.9	31.9	12	0.01	0.01
1977	20	0.04	0.20	20	0.019	0.035	52	4.4	24.5	52	10.3	25.4	20	0.01	0.02
1978	24	0.03	0.09	24	0.008	0.019	55	4.5	25.2	55	11.5	44.1	24	0.00	0.00
1979	32	0.03	0.07	32	0.005	0.011	54	5.1	12.6	54	11.5	30.3	32	0.00	0.02
1980	23	0.02	0.05	23	0.004	0.008	53	4.8	10.8	53	10.8	23.5	23	0.00	0.01
1981	55	0.04	0.42	55	0.004	0.018	58	4.5	14.3	58	11.1	36.4	55	0.00	0.02

Table A6. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12013															
1976	17	0.006	0.035	17	0.028	0.113	17	0.15	0.28	22	5.8	21.9	17	0.8	2.0
1977	19	0.007	0.033	19	0.033	0.101	19	0.14	0.35	24	7.2	26.3	19	0.8	1.8
1978	23	0.003	0.012	23	0.032	0.116	23	0.09	0.26	57	6.6	23.1	23	0.5	1.0
1979	22	0.002	0.009	22	0.016	0.055	22	0.13	0.60	56	5.5	29.5	22	0.5	0.9
1980	11	0.001	0.002	11	0.009	0.025	11	0.12	0.37	49	2.6	7.7	11	0.3	0.7
1981	53	0.002	0.011	53	0.008	0.029	53	0.14	0.31	56	1.8	6.4	53	0.3	1.2
12014															
1978										54	2.8	8.2			
1979										52	3.0	8.3			
1980										51	2.2	5.4			
1981	49	0.003	0.010	49	0.006	0.026	49	0.15	0.33	54	1.9	6.8	49	0.5	1.7
12015															
1978										55	4.0	15.4			
1979										48	3.9	11.3			
1980										52	3.0	8.3			
1981	58	0.004	0.022	57	0.009	0.037	57	0.13	0.29	57	2.5	5.8	57	0.3	1.4
12016															
1978										56	3.8	12.5			
1979										52	3.1	10.1			
1980										52	2.6	6.2			
1981										10	1.7	3.3			
12032															
1976										40	4.1	8.4	15	0.5	1.3
1977										29	3.5	17.9	26	0.5	0.9
1978										49	3.1	9.6	37	0.4	2.1
1979										43	3.6	9.6	58	0.3	1.4
1980										32	2.3	5.8	33	0.3	0.6
1981	5	0.003	0.009	5	0.011	0.018	5	0.19	0.29	56	1.4	8.2	57	0.2	0.4

Table A6. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12039															
1978										33	6.3	55.8			
1979										56	3.4	24.6			
1980										54	3.1	37.0			
1981										59	1.8	10.4			

Table A6. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12013															
1976	17	0.38	1.94	17	0.004	0.029	59	4.5	15.0	59	8.3	21.0	17	0.01	0.02
1977	19	0.39	2.02	19	0.031	0.069	54	6.1	32.0	54	13.1	33.6	19	0.02	0.07
1978	23	0.24	0.95	23	0.013	0.058	56	6.6	22.8	56	14.7	48.4	23	0.00	0.03
1979	22	0.15	0.38	22	0.011	0.025	56	7.2	22.9	56	15.0	41.9	22	0.00	0.01
1980	11	0.11	0.47	11	0.007	0.012	54	6.0	19.4	54	13.0	26.9	11	0.01	0.01
1981	53	0.06	0.20	53	0.004	0.017	56	6.3	14.7	56	14.1	33.8	53	0.01	0.02
12014															
1981	49	0.07	0.22	49	0.010	0.094	49	5.5	13.6	49	12.6	36.2	49	0.01	0.02
12015															
1981	52	0.08	0.22	57	0.008	0.047	55	6.0	17.3	55	14.3	32.3	51	0.01	0.02
12032															
1981	5	0.17	0.45	5	0.006	0.013	57	5.5	18.1	55	13.6	29.3	5	0.01	0.01

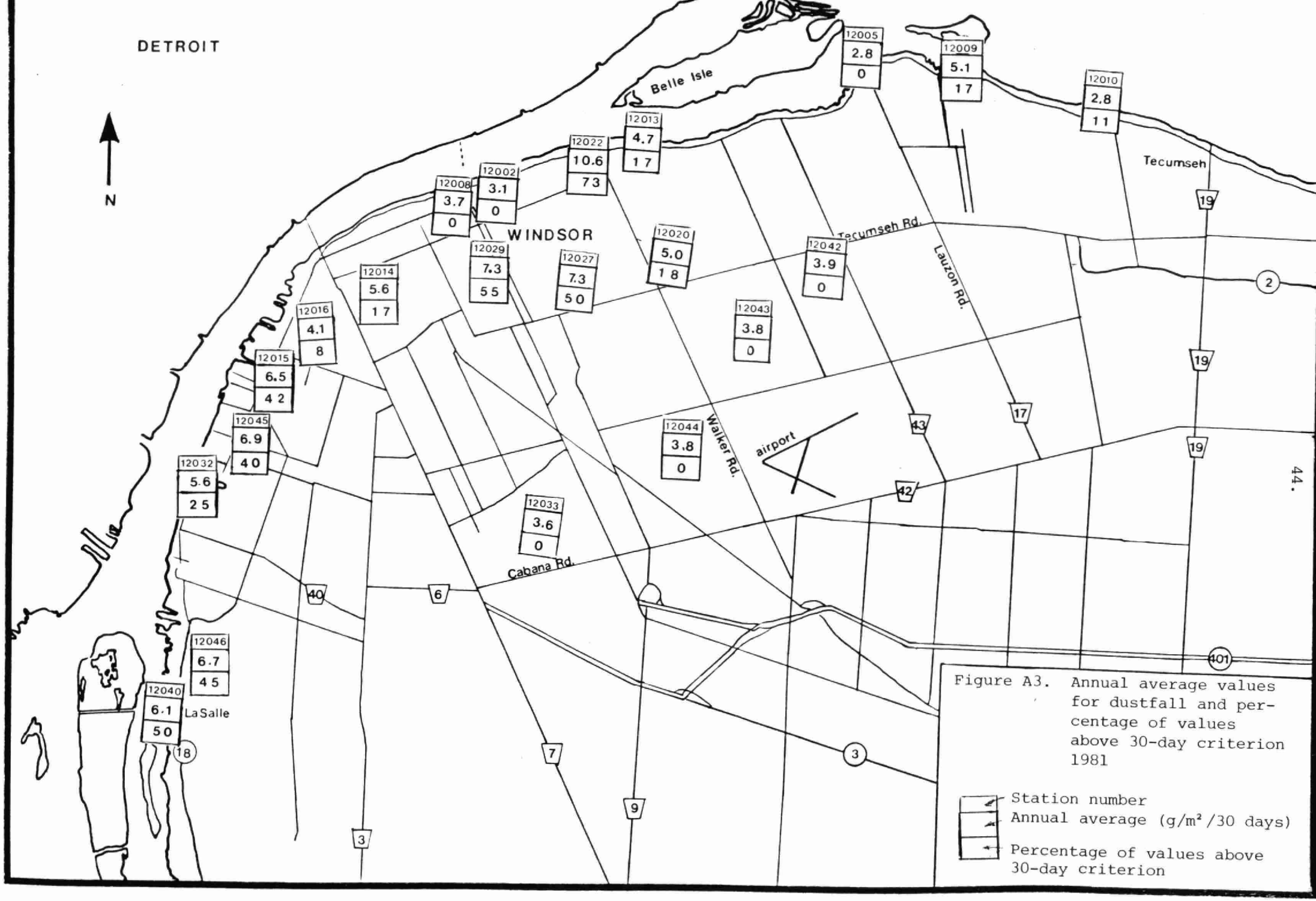

DETROIT
Belle Isle
N
WINDSOR
Tecumseh
Tecumseh Rd.
Lauzon Rd.
Walker Rd.
airport
Cabana Rd.
LaSalle
12005 2.8 0
12009 5.1 17
12010 2.8 11
12013 4.7 17
12022 10.6 73
12002 3.1 0
12008 3.7 0
12020 5.0 18
12042 3.9 0
12029 7.3 55
12027 7.3 50
12014 5.6 17
12016 4.1 8
12043 3.8 0
12015 6.5 42
12045 6.9 40
12044 3.8 0
12032 5.6 25
12033 3.6 0
12046 6.7 45
12040 6.1 50
Figure A3. Annual average values for dustfall and percentage of values above 30-day criterion 1981
Station number
Annual average (g/m²/30 days)
Percentage of values above 30-day criterion

Table A7. Levels of dustfall during 1981

Station Number	Dustfall loading ($g/m^2/30$ days)												Annual Average	Percentage of values above monthly criterion
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec		
12002	1.8	2.6	3.6	4.8	3.6	3.9	2.8	3.1	4.5	2.5	2.5	1.1	3.1	0
12005	1.8	1.4	2.9	5.6	3.3		4.0	2.2	3.2	2.9	1.6	1.5	2.8	0
12008	2.3	3.7	2.8	5.9	3.8	4.4	3.3	4.4	4.3	3.8	4.3	1.4	3.7	0
12009	1.1	7.4	2.4	4.9	3.3	28.6	1.0	2.2	5.1	2.6	1.2	1.2	5.1	17
12010	1.1	1.2	1.9	4.3	2.7				7.3	4.4	1.6	1.0	2.8	11
12013	1.3	2.8	4.3	7.7	4.0	8.7	5.1	4.9	6.6	5.4	3.7	2.0	4.7	17
12014	2.5	5.6	6.3	8.9	5.5	6.5	3.4	4.0	10.7	5.2	4.8	3.2	5.6	17
12015	5.6	7.1	5.8	8.3	7.1	8.8	5.1	6.2	8.5	6.0	3.8	5.1	6.5	42
12016	2.6	2.8	3.3	7.3	4.6	5.6	2.8	4.2	5.9	4.1	2.5	3.0	4.1	8
12020	1.3	4.1	4.4	8.0	5.4	12.3		6.0	5.3	4.1	3.0	1.6	5.0	18
12022	5.8	6.3	7.6	12.6	8.0	22.3	14.4	13.6	11.1	8.2	6.4		10.6	73
12027	5.5	9.4	6.6	11.0	7.5	11.5	7.7	7.6	6.3	5.4	4.6	4.3	7.3	50
12029	2.2	4.8	3.7	8.1	7.9	8.1		15.1	6.3	5.9	7.8	10.6	7.3	55
12032	4.0	5.6	4.4	7.7	6.0	7.3	6.0	5.0	7.2	5.1	3.4	5.5	5.6	25
12033	3.0	2.9	3.4	6.8	6.2		2.0		4.3	3.4	2.3	1.6	3.6	0
12040	1.6	2.7	3.8	7.1	9.1	8.9	7.1	8.7	5.7	6.7	10.0	1.6	6.1	50
12042	1.8	3.4	2.8	4.2	5.8	6.9	6.7	5.5	3.7	3.1	1.8	0.9	3.9	0
12043		2.8	3.7	5.8	6.4	3.8	4.3	3.6	4.2	4.2	2.0	1.1	3.8	0
12044	1.8		6.2	4.5	5.0	3.0	5.6	3.8	4.0	3.7	2.4	2.1	3.8	0
12045	3.4	3.0	6.3		13.1		12.4	7.8	8.8	6.1	5.4	3.1	6.9	40
12046	2.5	3.9	6.3	7.8	10.0		13.5	10.3	8.7	5.4	3.1	2.6	6.7	45

APPENDIX 3

SULPHUR OXIDES

Table A8. Summary of 1981 data for sulphur dioxide

Parameter	Station number 12008	12013	12016	12032
Annual average (ppm)	0.01	0.01	0.01	0.01
Percentage of values greater than:				
1-hour criterion	0	0	0	0
24-hour criterion	0	0	0	0
Highest 1-hr value (ppm)	0.27	0.34	0.14	0.19
Highest 24-hr value (ppm)	0.05	0.05	0.06	0.03

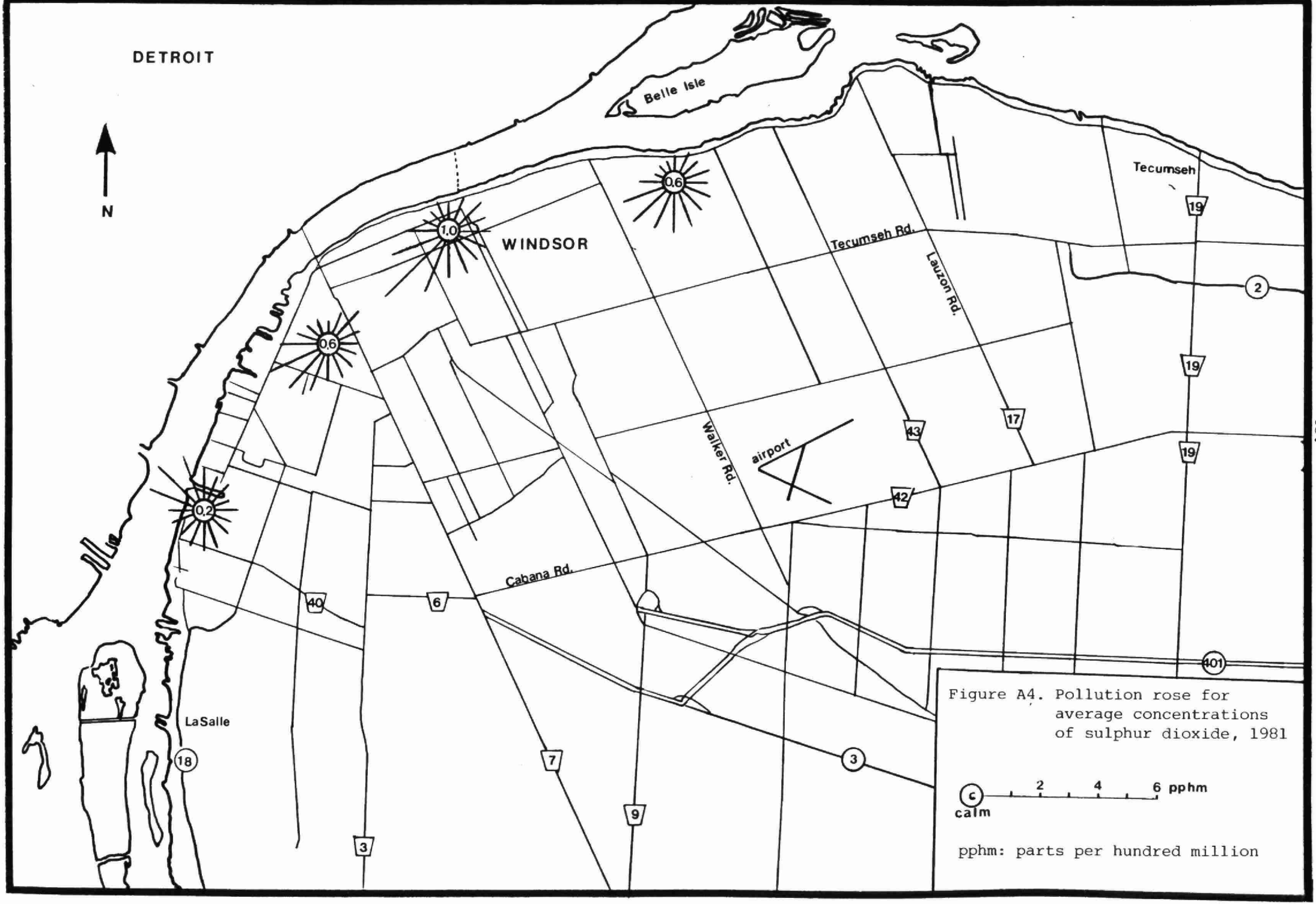


Figure A4. Pollution rose for average concentrations of sulphur dioxide, 1981

pphm: parts per hundred million

APPENDIX 4

TOTAL REDUCED SULPHUR, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A9. Summary of data for total reduced sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and ozone.

Parameter	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Total reduced sulphur										
Annual average (ppb)	0.5[b]									
Percentage of values greater than:										
1-hour criterion	0.06									
Carbon monoxide										
Annual average (ppm)	1	2	2	2	2	4	5	5	5	5
Percentage of values greater than:										
1-hour criterion	0	0	0	0	0	0	0	0	0.01	0
8-hour criterion	0	0	0	0	0	0	0.32	0.30	0.10	0
Nitrogen dioxide										
Annual average (ppm)	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03		
Percentage of values greater than:										
1-hour criterion	0	0	0	0.01	0	0	0	0		
24-hour criterion	0	0	0	0	0	0	0	0		
Nitric oxide										
Annual average (ppm)	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04		
Total oxides of nitrogen										
Annual average (ppm)	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.07		
Total hydrocarbons										
Annual average (ppm)	2.1	2.2	1.9[a]	2.3	2.4	2.6	2.2	1.9	2.1	2.2
Reactive hydrocarbons										
Annual average	0.4									
Ozone										
Annual average (ppm)	0.019	0.020	0.016	0.018	0.021	0.021	0.017	0.014		
Percentage of values greater than 1-hour criterion	1.3	1.8	0.8	2.4	3.1	2.5	2.2	0.8		

(a) 9 months of data
(b) 8 months of data

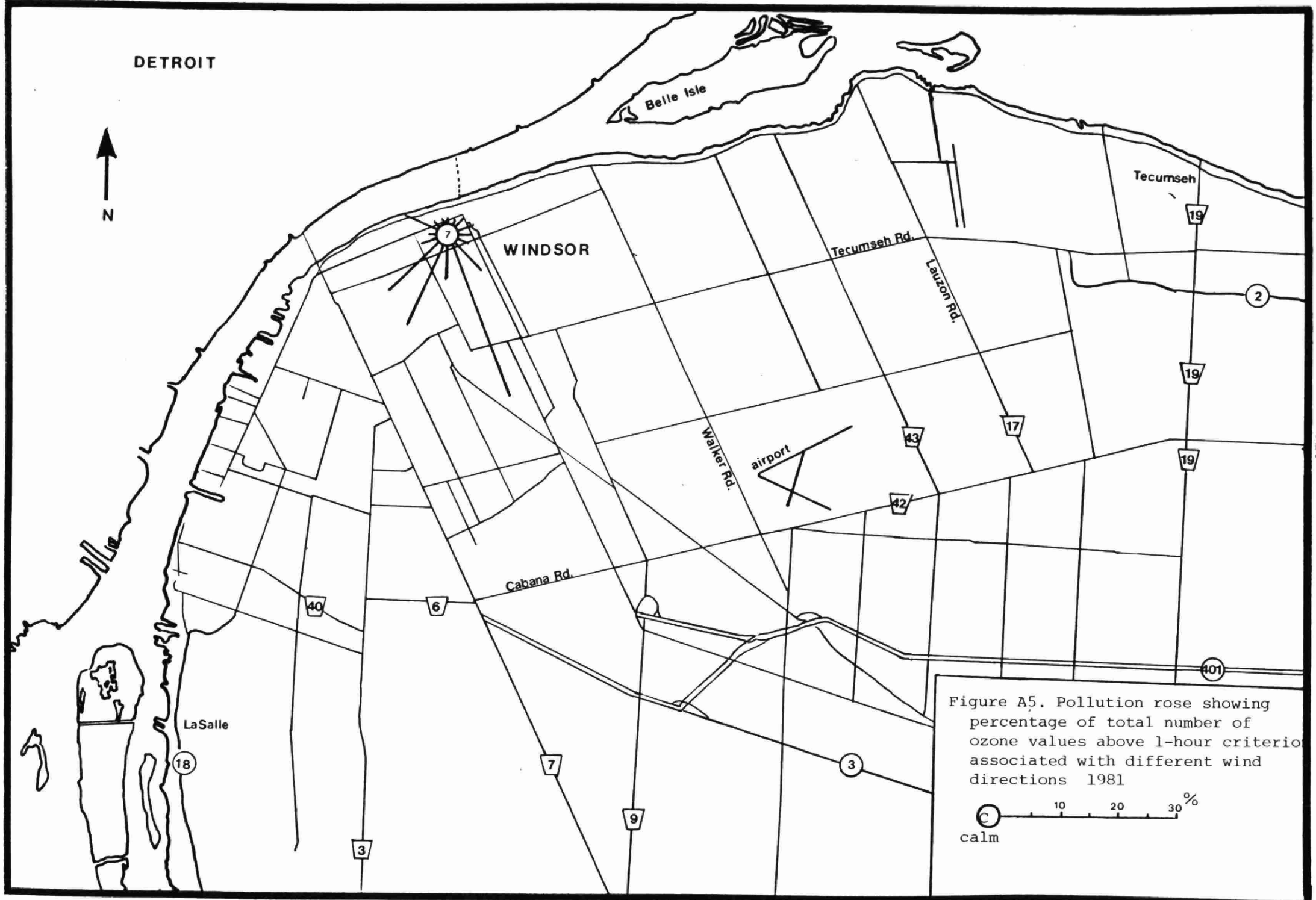


Figure A5. Pollution rose showing percentage of total number of ozone values above 1-hour criterio associated with different wind directions 1981

C 10 20 30 %

calm

APPENDIX 5

FLUORIDES

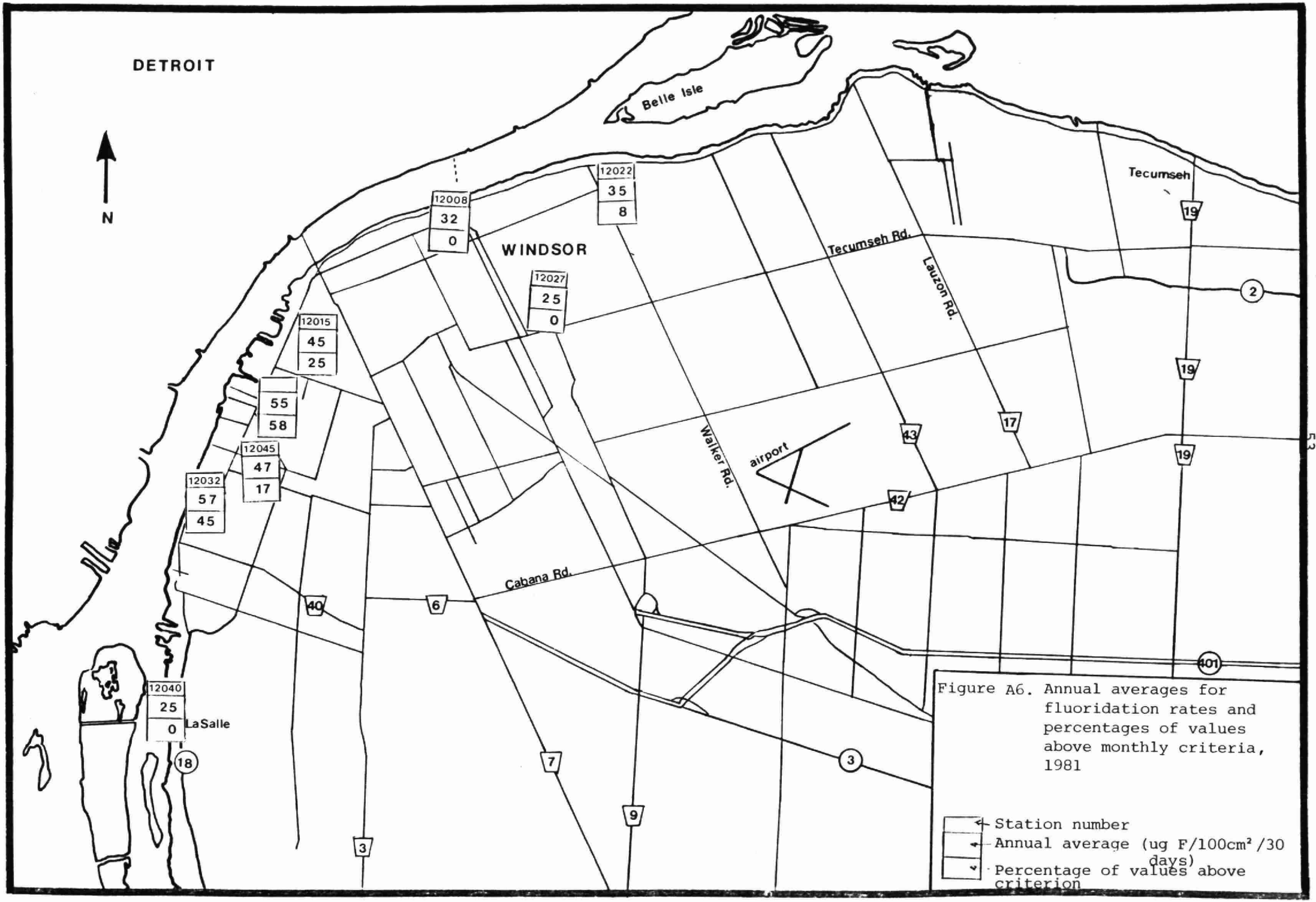


Figure A6. Annual averages for fluoridation rates and percentages of values above monthly criteria, 1981

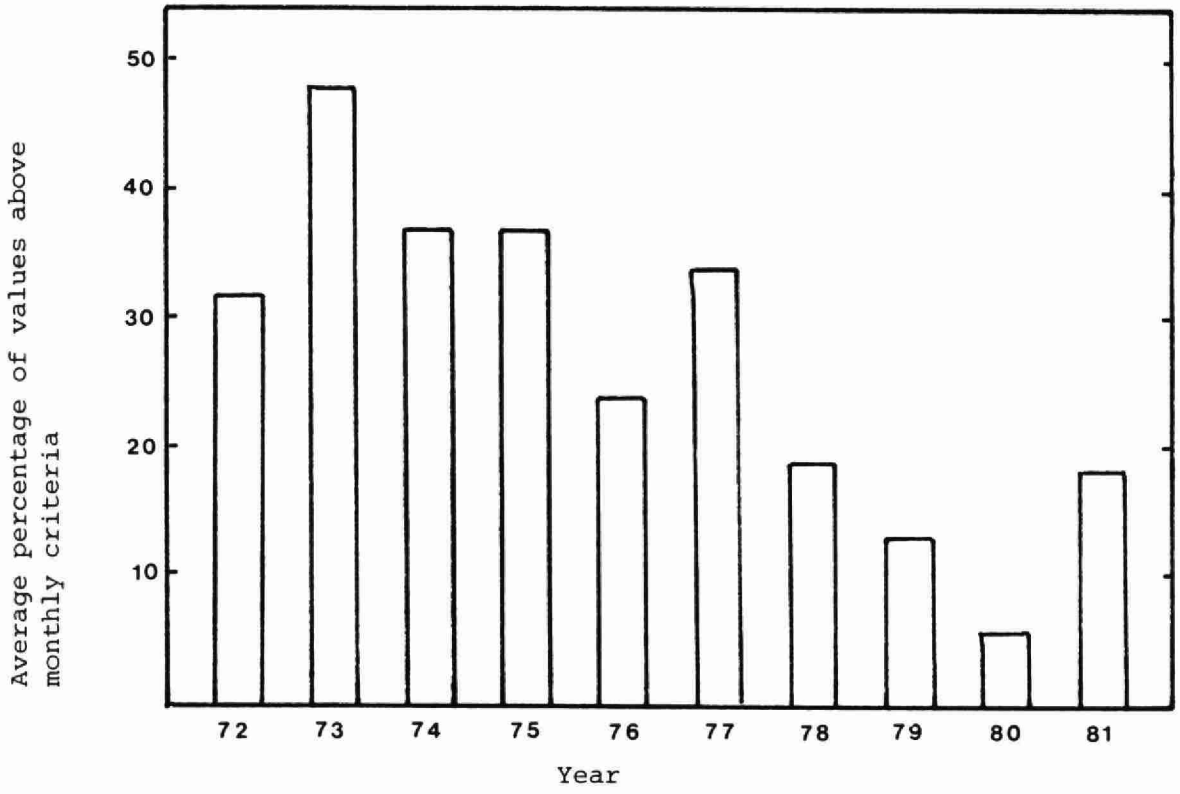
Station number
Annual average (ug F/100cm²/30 days)
Percentage of values above criterion

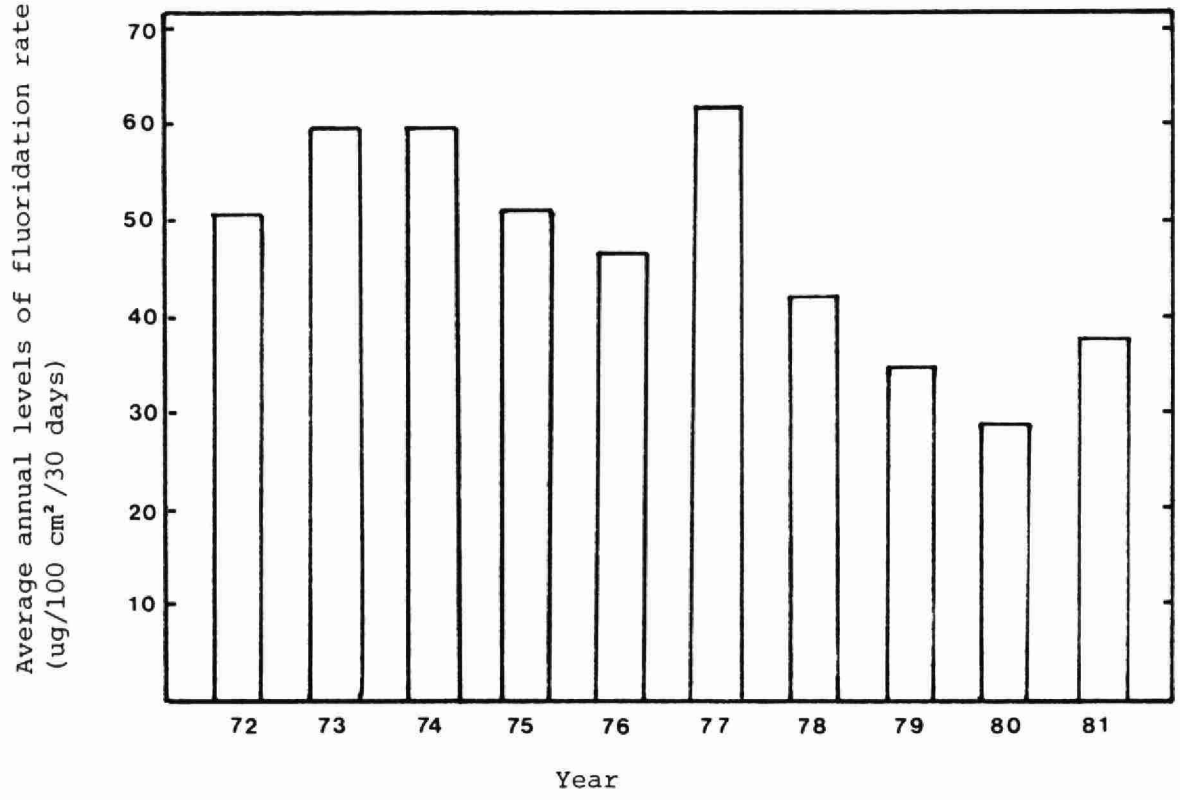
Table A10. Levels of fluoridation rate during 1981

Station Number	Fluoridation rate (ugF/100 cm²/30 days) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average	Percentage of values above criteria
12008	31	61	26	45	28	37	24	30	22	21	28	34	32	0
12015	48	95	42	77	43	69	32	47	46	37	39	83	55	58
12016	46	114	36	67	18	51	19	30	29	37	41	51	45	25
12022	24	142	17	33	24	32	19	30	19	21	29	26	35	8
12027	20	42	16	30	19	31	18	28	21	18	22	29	25	0
12032	56	137		80	41	64	35	38	41	32	46	54	57	45
12040	26	32	23	27	25	21	17	19	20	24	22	41	25	0
12045	72	85	37	60	28	53	24	33	36	28	37	73	47	17

Note: Underlined values exceed criteria for desirable ambient air quality

Figure A7. Trend in levels of fluoridation rate based on averaged data for six monitoring stations





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